Appendix E. Analysis of roadside data

E.1. Summary

BAR undertook an extensive roadside testing program to provide data for program evaluation. Under the roadside program, vehicles were randomly selected and pulled over by a highway patrol officer. Motorists were asked if they would voluntarily submit their vehicle to emissions testing at the roadside. The testing involved the same inspections (ASM emissions, visual, and functional tests) as are performed in the Smog Check program (in some cases not all visual or functional tests were performed).

The advantages of the roadside data are that the vehicles tested are a potentially unbiased sample of on-road vehicles. Because the program was voluntary, almost 10% of motorists refused to participate. Vehicles were tested at sites in nearly 1,500 zip-codes throughout the Enhanced areas of the state. More older vehicles were intentionally selected for testing to get large enough samples of vehicles with the highest emissions levels. All of the vehicles tested under the Roadside program were given a full ASM test, so the measured emissions were not affected by some vehicles receiving a shorter test than others. And because the test sites were located at roadside, most of the vehicles tested had been warmed up prior to testing.

Nonetheless, there are some disadvantages of the Roadside data. Random roadside ASM testing is costly and time-consuming. An individual crew consisting of three or four Bureau of Automotive Repair (BAR) technicians, one CHP officer, and a portable dynamometer can measure about 25 vehicles per day. As a result, it took nearly three years (from February 1997 to October 1999) for the BAR to accumulate the 30,000 vehicle tests in this database. Care must be taken when comparing emissions of Enhanced-tested vs. untested vehicles, either in aggregate or by model year, because vehicles of the same model year were older at the end, compared to the beginning, of the data collection period. To the extent that Enhanced-tested and untested vehicles were measured at different sites, driver socioeconomic factors may influence average emissions and bias apparent program effects. As with the VID data, the emissions measured under the ASM test may not be representative of on-road emissions.

E.2. Data validity

As described above, roadside ASM testing began over a year before the start of the Enhanced Smog Check program. At that time there were no commercially available instruments to measure emissions on the ASM test. BAR used two different types of instruments to measure NOx emissions of vehicles tested at roadside before the start of Enhanced testing in June 1998. One or both of these instruments were not working properly during the testing of several vehicles. In addition, 17% of the roadside ASM 2525 NOx measurements made before June 1998 were zero measurements. Only 3% of the NOx readings after June 1998 were zero measurements. The fraction of zero HC and CO readings during roadside tests both before and after June 1998 were comparable to the fraction of HC and CO readings in the VID data, as shown in Table E.1. The different instrumentation used, and the high number of zero readings, raise questions about the accuracy of the NOx measurements of vehicles tested at roadside before June 8, 1998.

Table E.1. Fraction of all ASM 2525 tests with measurements of zero, by pollutant and test type

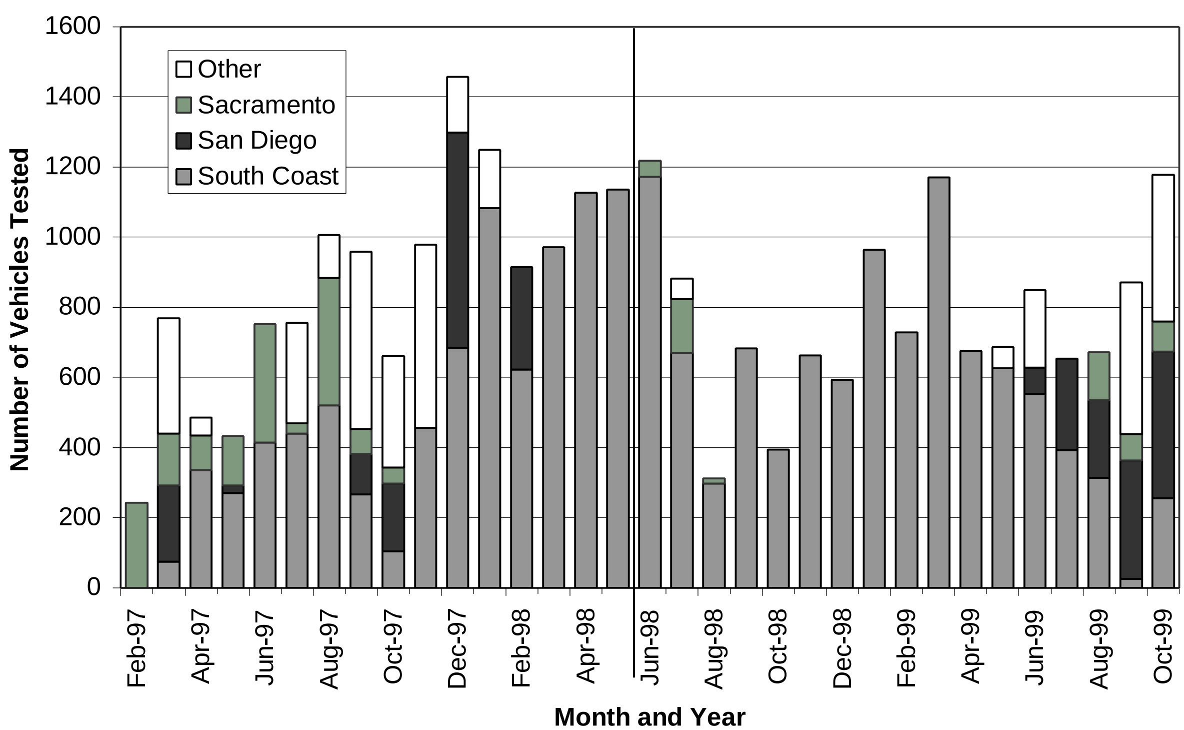
	HC	CO	NOx
Roadside tests before June 8, 1998	3.6%	19.5%	16.9%
Roadside tests after June 8, 1998	2.9%	13.1%	3.1%
Smog Check tests in VID	3.5%	14.7%	2.4%

We also apply our criteria for valid emissions measurements described in Appendix B to the roadside data. We find that only 68 vehicles, or less than 0.01% of all vehicles tested at roadside, did not meet our criteria for valid ASM 2525 measurements. We exclude these vehicles from our analysis.

E.3. Data analysis

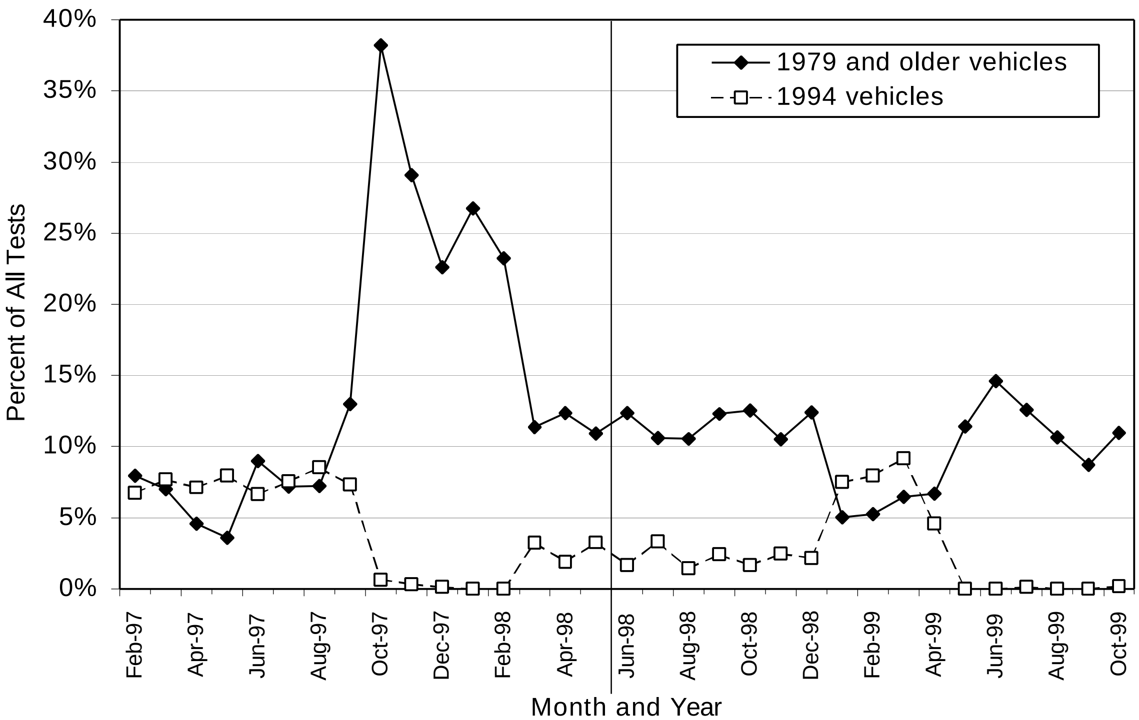
BAR's roadside testing program took place at hundreds of sites over a period of nearly three years. Figure E-1 shows the distribution of roadside vehicles by the region and month of testing. Nearly 80% of the vehicles tested after June 1998 were from the South Coast air basin; in contrast, only 62% of the roadside vehicles tested before June 1998 were from the South Coast. Almost all of the vehicles from other air basins were tested prior to June 1998. As discussed above, there are problems with the roadside tests prior to June 1998; therefore there are very few useable roadside measurements of vehicles operating in areas other than the South Coast air basin.

Figure E-1. Number of Roadside Vehicle Tests by Region and Month



In order to get representative samples of older vehicles, that tend to have the highest emissions and are most likely to be affected by the Smog Check program, BAR intentionally pulled over more older vehicles for roadside testing. Figure E-2 shows the percent of roadside tests of 1979 and older vehicles, and of 1994 vehicles, by test month. The figure indicates that the model year distribution of vehicles tested in the first seven months of the program were representative of the model year distribution of the on-road fleet. However, for long stretches of time, older vehicles were over-sampled in numbers larger than their representation in the on-road fleet. For example, from September 1997 through February 1998 over 20% of the vehicles tested were 1979 or older vehicles; virtually no 1994 vehicles were tested during these months.

Figure E-2. Percent of Roadside Vehicles Tested by Month, for Selected Model Years



Vehicles selected for roadside testing and pulled over are not required to participate in the program. Nearly 3,000 vehicles, or 10% of all vehicles pulled over, chose not to have their vehicle participate in the roadside testing program. Because participation is voluntary, there is concern that if the vehicles refusing to participate have higher emissions than those that do participate, then the sample of vehicles measured at roadside is not representative of the in-use fleet. BAR set up a remote sensing unit at some roadside sites to measure the HC and CO emissions of vehicles that refused to participate in the program. As a result, there are remote sensing measurements of 2,500 vehicles that chose to participate in the roadside testing, and 241 vehicles that did not. Figures E-3 and E-4 show average remote sensing HC and CO emissions, by model year, of the vehicles that participated in the program and those that did not. The figures indicate that the fleet of vehicles that refused to participate do not have higher emissions than the fleet that chose to participate. The average HC emissions of the non-participating fleet of vehicles are 8% lower, and the average CO emissions 2% lower, than the average emissions of the fleet of vehicles participating in voluntary roadside testing. Therefore, there does not appear to be a sample bias in the fleet of vehicles that chose to participate in roadside ASM testing.

Figure E-3. Average RSD HC for Roadside Participants and Non-Participants, by Model Year

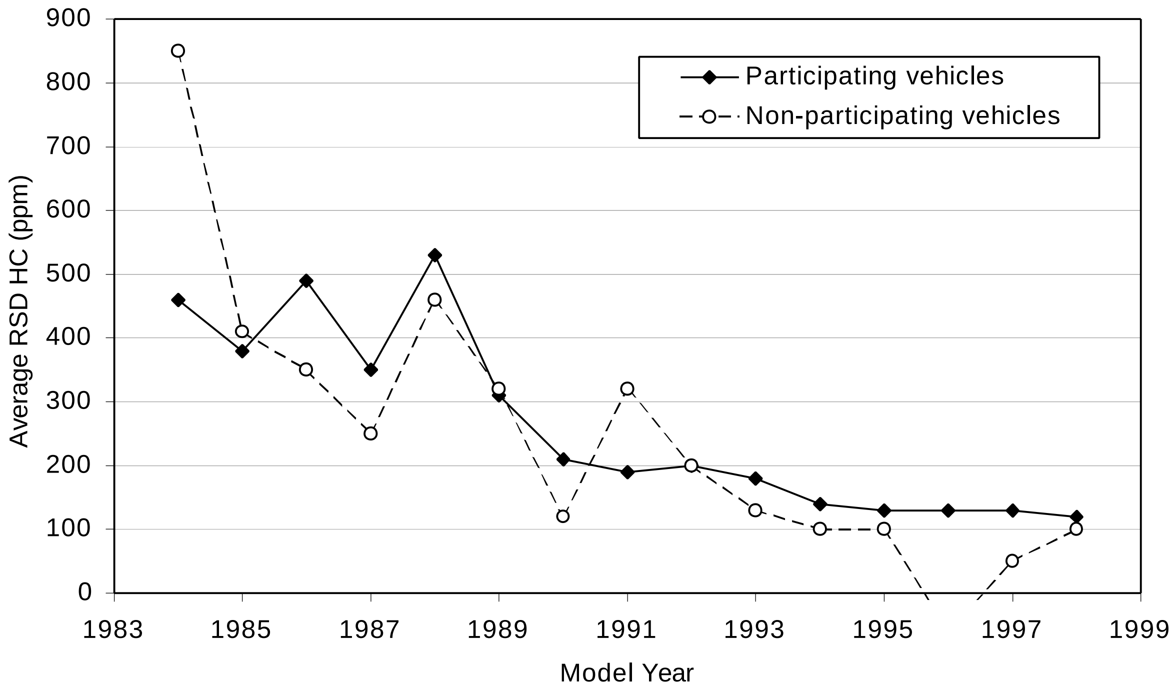
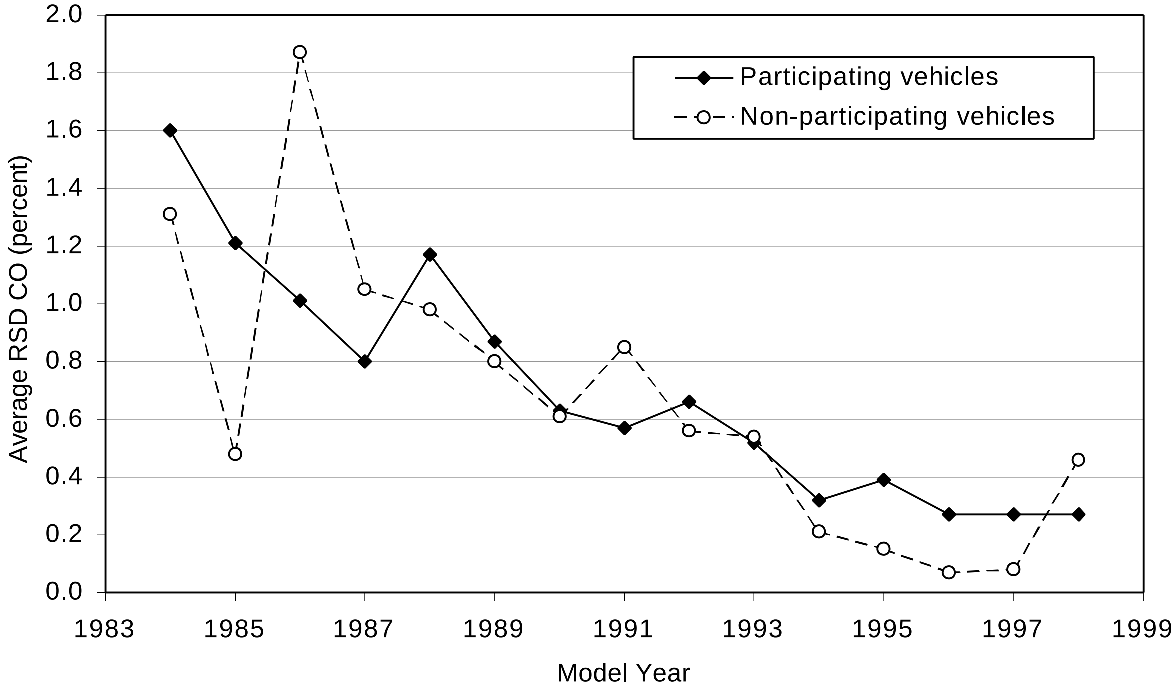


Figure E-4. Average RSD CO for Roadside Participants and Non-Participants, by Model Year



For our analysis we compare the roadside emissions of vehicles that had not yet participated in the Enhanced Smog Check program (the "Untested" fleet) with those of vehicles that had received an Enhanced Smog Check test (the "Tested" fleet). BAR provided us with a database of all VID records of vehicles with the same license plate and/or vehicle identification number as appear in the roadside test database. This database included over three years of VID data spanning the Basic and Enhanced programs (June 1998 to November 1999). To determine which vehicles had received an Enhanced test before their roadside test, we matched these VID data with the roadside test data, by license plate. We were able to match 80% of the vehicles with roadside emissions tests with VID test records; we assume that the remaining 20% of unmatched roadside vehicles have never been through the Smog Check program. Vehicles that had an Enhanced test prior to their roadside test were classified as Tested vehicles, whereas vehicles that had a Basic test prior to their roadside test, and/or had an Enhanced test after their roadside test, were classified as Untested vehicles. We refer to vehicles with no record of a Smog Check test as the "Never Tested" fleet.

Because the roadside testing occurred over nearly a three year period, a vehicle of a given model year tested after June 1998 would be on average one and a half years older than a vehicle of the same model year tested before June 1998. Since all of the Roadside tests before June 1998 are of the Untested fleet, including the pre-June 1998 tests would lower the average vehicle age, and therefore emissions, of the Untested fleet, and introduce a bias in our estimate of program effectiveness. Therefore, we limit the Untested fleet only to those vehicles with a roadside test after June 8, 1998.

We use these definitions of the Tested and Untested fleet solely to estimate the percentage reduction in emissions from the Enhanced program. This methodology differs slightly from our methodology to estimate the incremental benefits of the Enhanced program, as described in Section 4.4 and Appendix D. Table E.2 shows the average gram-per-gallon emissions of the Tested, Untested, and Never Tested fleets in the roadside data, by model year. As discussed above, the Tested fleet had their roadside test on average six months after their Enhanced Smog Check test. To estimate the full, one-cycle benefits of the Enhanced program, one should compare the emissions of the Tested fleet with a fleet of vehicles that has not had a Basic Smog Check test in the last 30 months (two years plus six months). However, since Smog Check requires biennial testing, virtually no vehicles will have gone substantially more than 24 months since their last Smog Check. Our estimate of the percentage reductions from the Enhanced program uses a subset of the Untested fleet that: (1) had their roadside test after June 8, 1998, and (2) had their last Basic Smog Check test more than 12 months before the roadside test and/or an Enhanced test after the roadside test. The average emissions of these vehicles are shown as the Untested fleet in Table E.2. (A second estimate of percentage reductions from the program, using the group of vehicles that could not be matched with our VID data, or the Never Tested fleet, is also shown in the table).

Table E.2. Number of roadside vehicles and average gram-per-gallon emissions by test fleet

Model Year	Never Tested (no VID record)				Untested (last test BAR 90)				Tested (last test BAR97)			
	Number	HC	CO	NOx	Number	HC	CO	NOx	Number	HC	CO	NOx
1974	20	95.7	500.6	94.3	32	42.8	584.8	72.2	16	68.4	350.6	95.0
1975	12	39.1	718.2	43.3	22	74.6	561.4	64.7	20	36.1	320.6	68.6
1976	14	60.3	468.2	49.1	32	61.0	371.0	53.4	27	27.4	610.3	56.5
1977	49	80.3	465.4	65.6	59	88.7	477.3	57.5	61	23.2	364.3	58.3
1978	49	83.3	436.7	68.1	90	68.7	572.1	60.4	60	29.9	359.7	63.6
1979	54	67.1	461.1	66.9	84	41.9	562.8	51.2	86	41.6	332.7	58.4
1980	49	76.5	768.4	48.1	84	27.1	639.6	68.2	69	23.1	496.6	56.4
1981	34	51.8	596.2	64.3	122	39.7	631.6	57.8	83	22.3	368.3	66.3
1982	44	75.7	533.5	51.5	138	36.4	641.5	61.1	123	34.6	391.3	48.0
1983	52	22.8	398.6	64.9	192	31.8	482.8	61.4	160	25.0	283.3	59.6
1984	85	32.1	588.5	46.2	294	33.0	480.2	54.8	258	17.6	240.2	45.7
1985	127	34.9	372.5	54.2	411	25.8	383.3	52.6	371	22.2	261.3	48.2
1986	146	24.3	347.4	48.7	470	18.3	203.7	47.3	450	15.0	171.1	41.4
1987	110	16.6	240.5	40.6	390	17.6	262.2	46.1	409	19.7	197.8	39.1
1988	118	16.5	187.6	36.6	355	16.6	160.3	39.3	397	12.2	109.1	29.5
1989	134	12.6	87.4	22.5	430	11.0	115.6	27.5	414	11.8	84.8	25.8
1990	134	11.1	115.0	26.5	372	7.9	64.8	21.6	355	8.9	71.1	22.0
1991	111	8.7	69.5	20.9	352	7.3	69.2	18.6	361	6.1	32.5	16.5
1992	30	11.7	125.7	19.6	124	7.5	72.4	18.7	82	7.3	61.6	18.4
1993	32	8.2	57.4	15.3	120	4.6	29.8	11.5	66	5.2	28.8	9.5
1994	50	4.5	31.7	13.3	120	4.5	21.3	10.3	114	4.5	31.7	9.1
1995	44	4.2	14.8	11.9	175	4.4	20.6	8.5	47	3.9	18.8	8.5
1996	163	3.4	14.3	8.2	77	3.1	10.9	6.5	24	3.4	12.3	7.5
1997	86	3.6	14.3	13.1	5	2.5	1.5	2.9	4	1.3	0.9	7.2
1998	108	2.4	5.9	2.6	3	1.6	1.2	8.2	2	2.6	3.6	0.2
1999	11	2.3	5.6	1.4	0				0			
Total or wtd avg	1866	17.8	180.4	29.2	4553	14.5	165.7	28.5	4059	11.7	116.4	26.0
Tested fleet % redn		34%	35%	11%		17%	28%	9%				

The last two rows of Table E.2 present the weighted average emissions for each fleet, and the percent reduction of the Tested fleet compared to the Never Tested and Untested fleets. The table indicates that, compared to the Untested fleet, the Enhanced program results in emissions reductions of 17% for HC, 28% for CO, and 9% for NOx. Figures E-5 through E-9 show the number of vehicles, the time since last Smog Check test, and the average emissions of the Tested, Untested, and Never Tested roadside fleets by model year.

Figure E-5. Number of Vehicles with Roadside Test by Fleet and Model Year

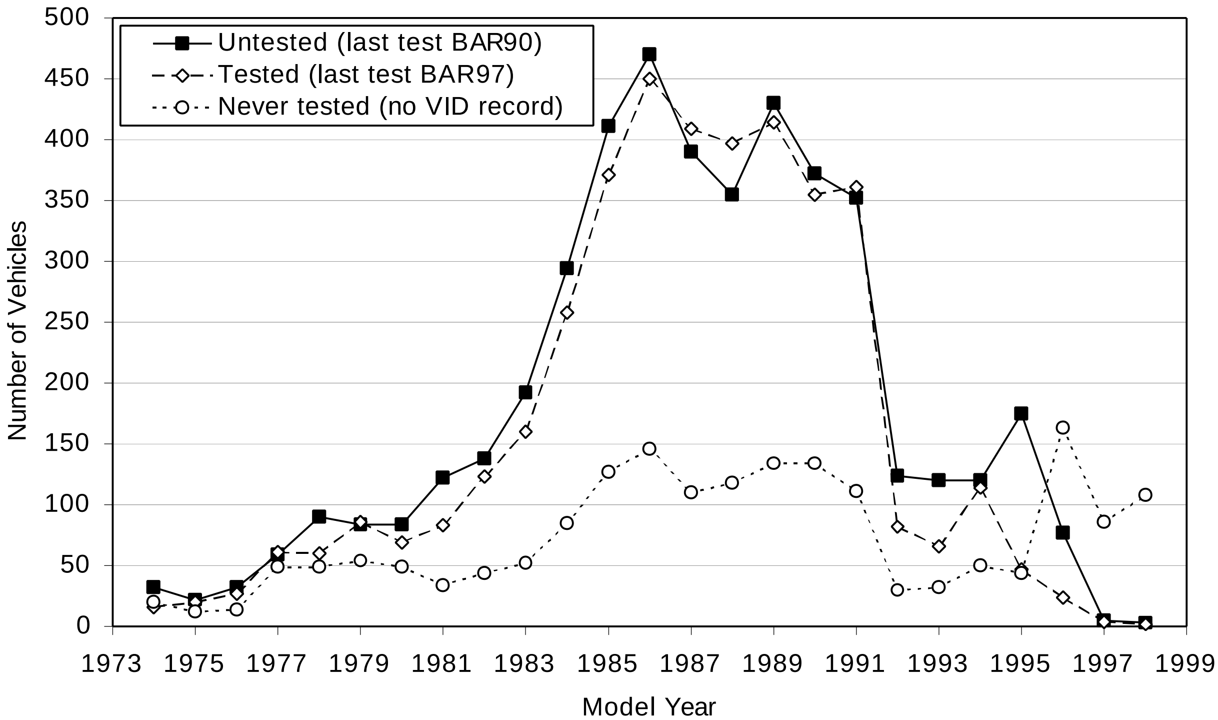


Figure E-6. Average Time since Last Smog Check Test
by Fleet and Model Year

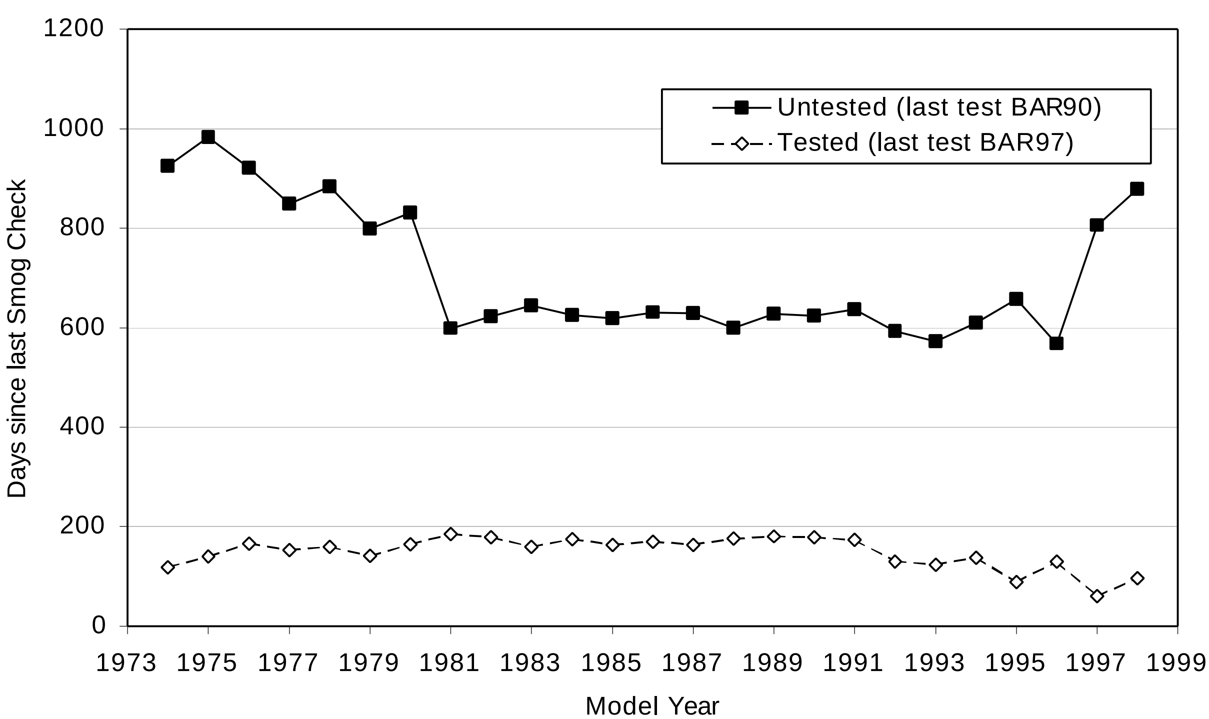


Figure E-7. Average Roadside HC 2525 Emissions by Fleet and Model Year

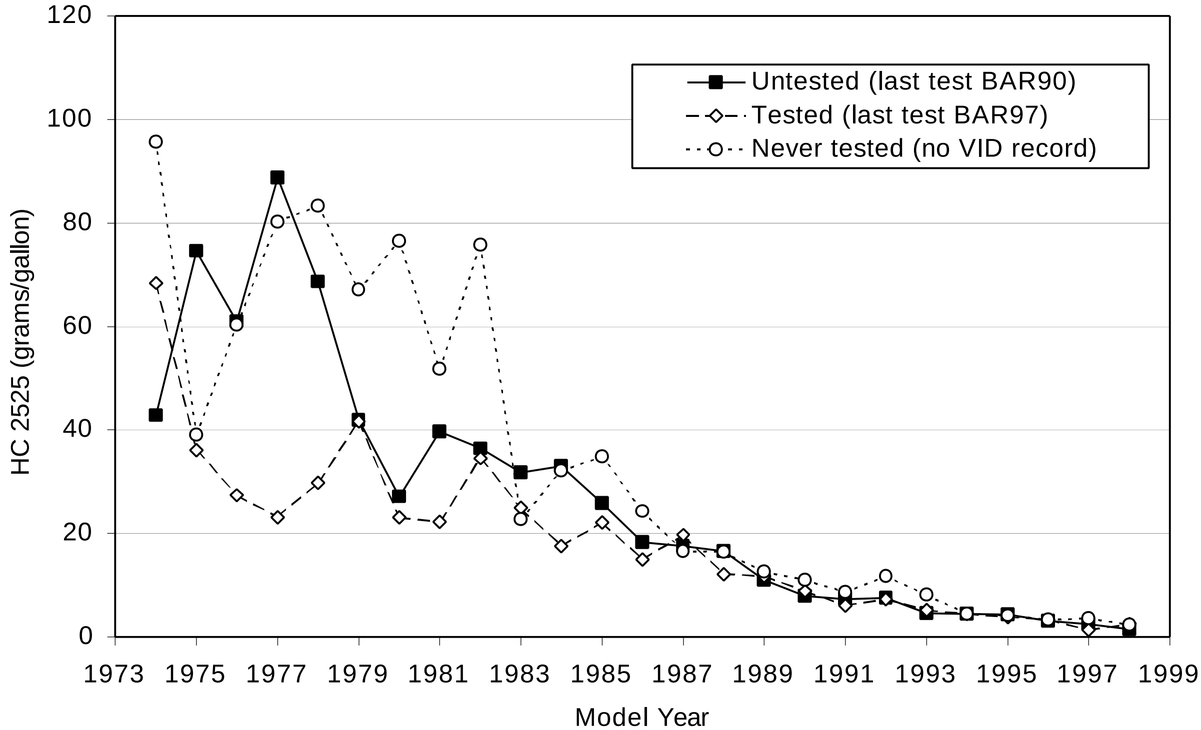


Figure E-8. Average Roadside CO 2525 Emissions by Fleet and Model Year

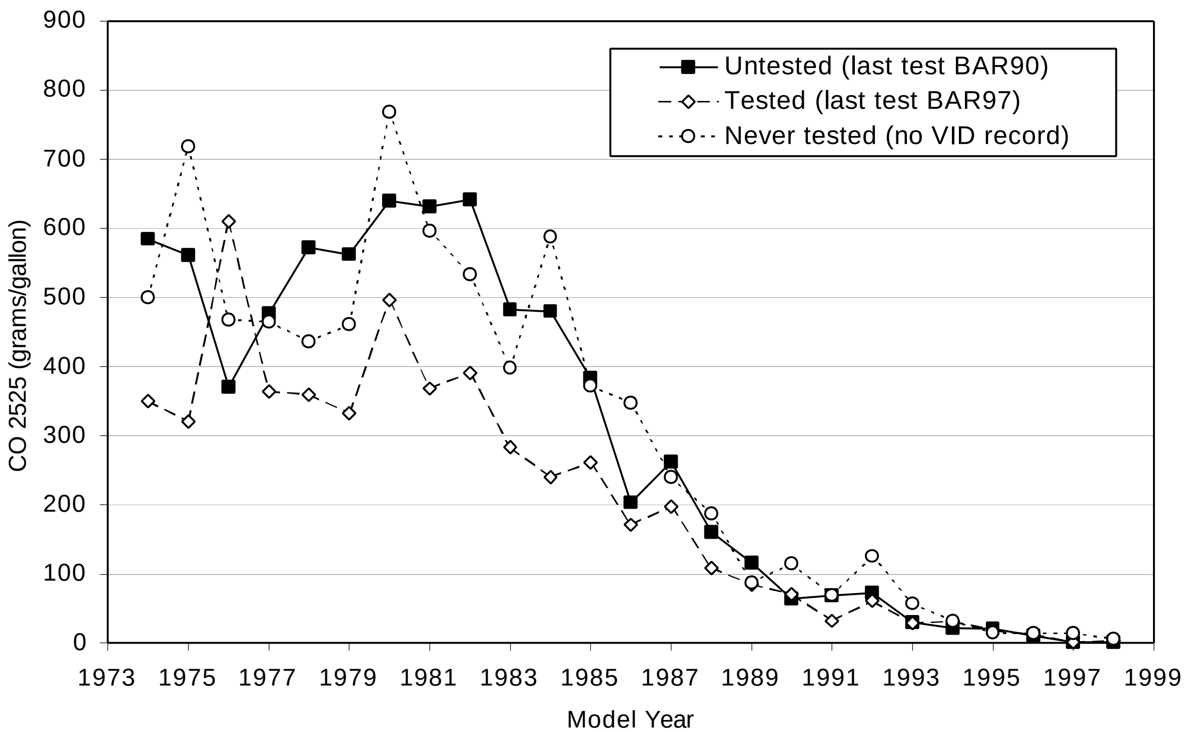
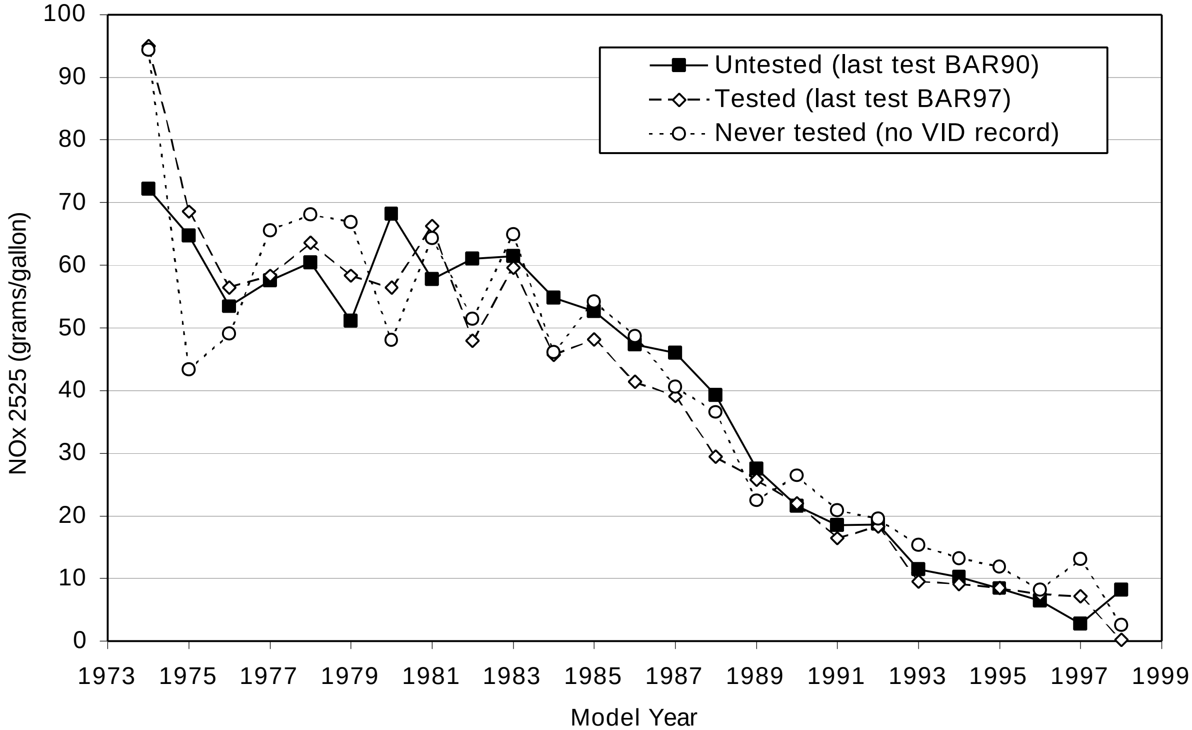


Figure E-9. Average Roadside NOx 2525 Emissions by Fleet and Model Year



Appendix F. Analysis of remote sensing data

F.1. Summary

"Remote sensors" are devices that can remotely measure the emissions of vehicles as they are being driven on single-lane roads or freeway ramps. They measure the ratio of CO and HC to CO2 in a vehicle's exhaust plume using infrared absorption; this is the same technique used by the Smog Check test equipment. Remote sensors measure NOx with a technique used in Smog Check test equipment. Remote sensors also measure the speed and acceleration of each vehicle as it drives by the sensor; these data can be combined with the roadway grade at the site and typical vehicle characteristics to estimate the instantaneous load on the vehicle at the time of measurement. A video camera placed alongside the remote sensor records each vehicle's license plate, which is stored together with the emissions measurement. Vehicle information is obtained by matching the license plate with registration records. A single remote sensing instrument can measure emissions of thousands of vehicles per day, for a small fraction of the cost of conducting a similar number of ASM tests. The operation and validation of remote sensors have been described extensively in peer-reviewed literature.[1]

Remote sensing data were provided to the IMRC by the Steven and Michele Kirsch Foundation, Professor Donald Stedman of the University of Denver, Environmental Systems Products, and the Coordinating Research Council. The data include approximately 155,000 valid vehicle emissions measurements at three sites in the Los Angeles area, three sites in Sacramento, and one site in San Jose. This study focused on the measurements from the greater Los Angeles area as described below in the Data Validity section.

Remote sensing data has unique advantages over the program test results (VID data) and random roadside ASM tests. Remote sensing measurements best represent the emissions of the on-road fleet during warmed-up driving. The emissions of most vehicles driving by the sensors are measured, and there is little incentive to avoid measurement. The measurement is unscheduled, so there is no opportunity (or incentive) to prepare a vehicle prior to measurement. All the remote sensing measurements were made over a relatively short time period, so vehicle aging is less of an issue than with the Roadside ASM test data. The remote sensing data can also be used to identify vehicles that never pass Smog Check yet are still being driven in Enhanced areas, as well as vehicles that are unregistered.

However, there are also some disadvantages of the remote sensing data. Because remote sensors measure an individual vehicle's emissions during only a fraction of a second, the measurement is an imprecise, though accurate, estimate of a given vehicle's emissions at the time of testing. For comparison, an ASM test records 20 to 270 one-second measurements. This individual measurement imprecision is typically overcome by sampling tens of thousands of vehicles to obtain very accurate, fairly precise fleet average emissions estimates. Better precision requires the sampling of more vehicles.

1. For starters, see: Bishop, G.A., J.R. Starkey, A. Ihlenfeldt, W.J. Williams, D.H. Stedman. (1989). "IR long-path photometry: a remote sensing tool for automotive emissions." *Analytical Chemistry*. V61, 671A-677A. Zhang, Y., D.H. Stedman, G.A. Bishop, P.L. Guenther, S.P. Beaton, J.E. Peterson. (1993). "On-road hydrocarbon remote sensing in the Denver area." *Environmental Science & Technology*, V27, 1885-1891.

The Smog Check program mostly affects the roughly 40% of on-road vehicles that are more than 10 years old and the roughly 15% of vehicles that fail their test. Therefore, evaluating Smog Check program effectiveness requires even larger numbers of remote sensing measurements. The remote sensing data available for this study were insufficient in number to make precise quantitative estimates of program effectiveness, and measurements were made at too few sites to know whether the observed trends apply throughout all Enhanced Smog Check areas. Nevertheless, the data are extremely valuable as the only emissions measurements made under typical real-world driving conditions.

F.2. Data validity

In total the IMRC obtained approximately 155,000 valid remote emissions measurements. Of these, about 144,000 (93%) had an apparently valid license plate reading and about 115,000 (74%) were successfully matched to Department of Motor Vehicles records. Summary statistics on the data are provided in Table F-1. The validity of a single pollutant emissions measurement is evaluated by the remote sensing software and provided with the measurement record. Since all pollutants are measured by ratio to CO_2, all measurements must have at least a valid CO_2 reading.

Table F-1. Summary of remote sensing data available for this study

	All Sites	Los Angeles area
Total records	177,845	66,790
Valid CO_2	156,580	60,649
Valid CO	155,508	60,383
Valid HC	153,092	59,814
Valid NOx	154,478	60,277
Valid speed & accel	151,552	53,635
Apparently valid in-state license	144,353	53,787
Match to DMV	115,235	43,023
Match to any Smog Check record	81,510	35,828

The remote sensing data were analyzed as follows. Gram-per-gallon emissions factors were calculated for each pollutant and each vehicle measured using the equations presented in Appendix D. In order to maximize the data available for analysis, we used records with valid emissions data for CO and CO_2, even if the HC or NOx measurements were invalid. Likewise, if only HC or NOx were available (in addition to CO or CO_2), the valid measurement was included, and the invalid pollutant measurement excluded, for the given vehicle record.

The emissions measurement records were matched to the Department of Motor Vehicles database to extract information about the vehicles measured. Data from the Riverside site were matched to the database current at the time of measurements and we received only those measurements with matched license plates (i.e. vehicle information included). Remote emissions measurements from the other sites were matched to the October 1998 “filepass” that we received from the DMV. We presume that many of the license plates that had no matches in this database were new or vehicles that arrived in California during the past year.

Figures F-1 through F-3 show the average gram-per-gallon emissions by model year, of HC, CO, and NOx as measured at the seven sites for which remote sensing data were available. These figures show several important trends. First, emissions of two to four year old vehicles are similar across most sites for each pollutant. This is expected since these vehicles should be overwhelmingly free of emissions related problems, and thus not subject to site-to-site differences in maintenance and repair**.**

Figure F-1. HC emissions at seven remote sensing sites.

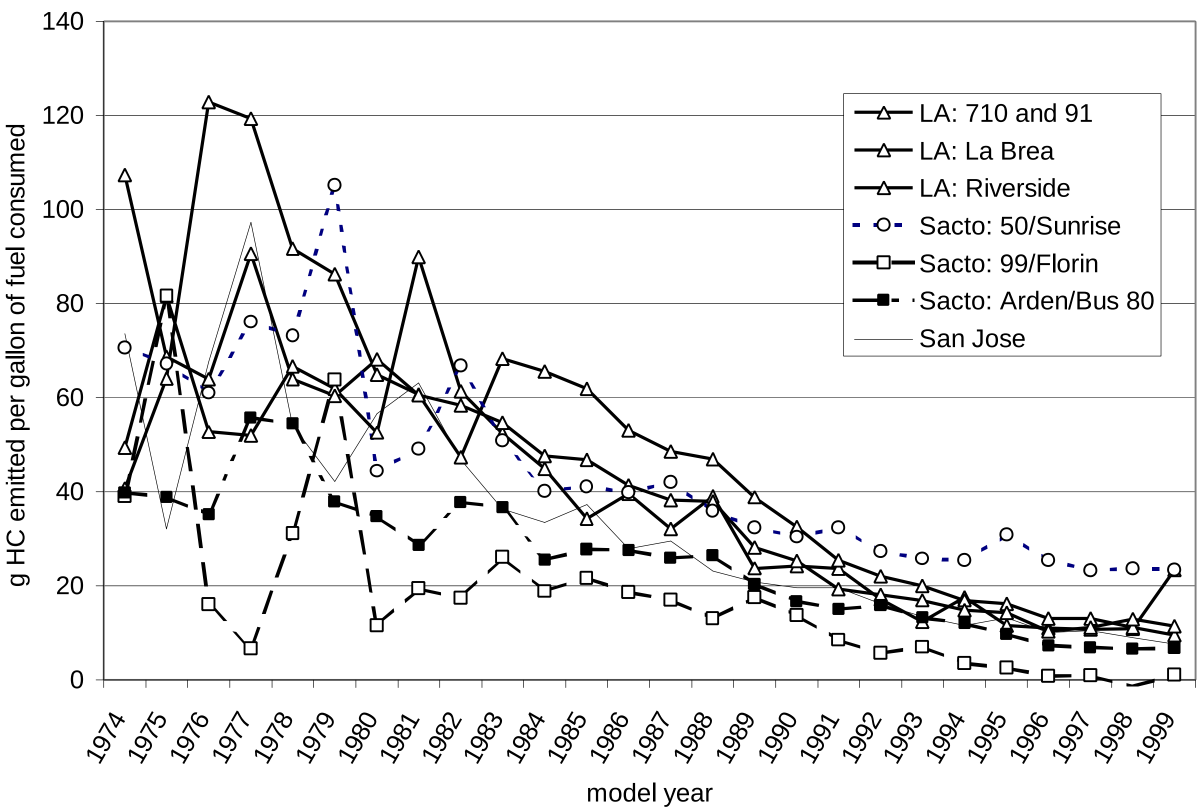


Figure F-2. CO emissions at seven remote sensing sites

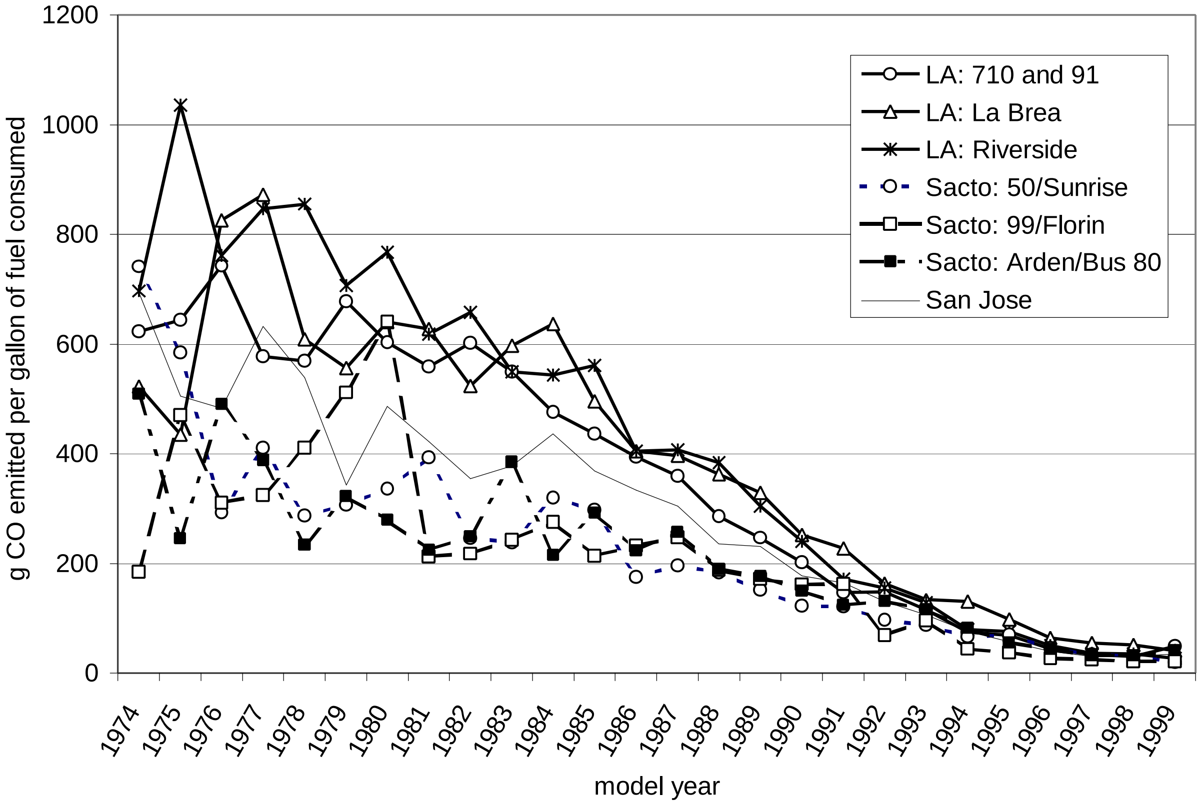
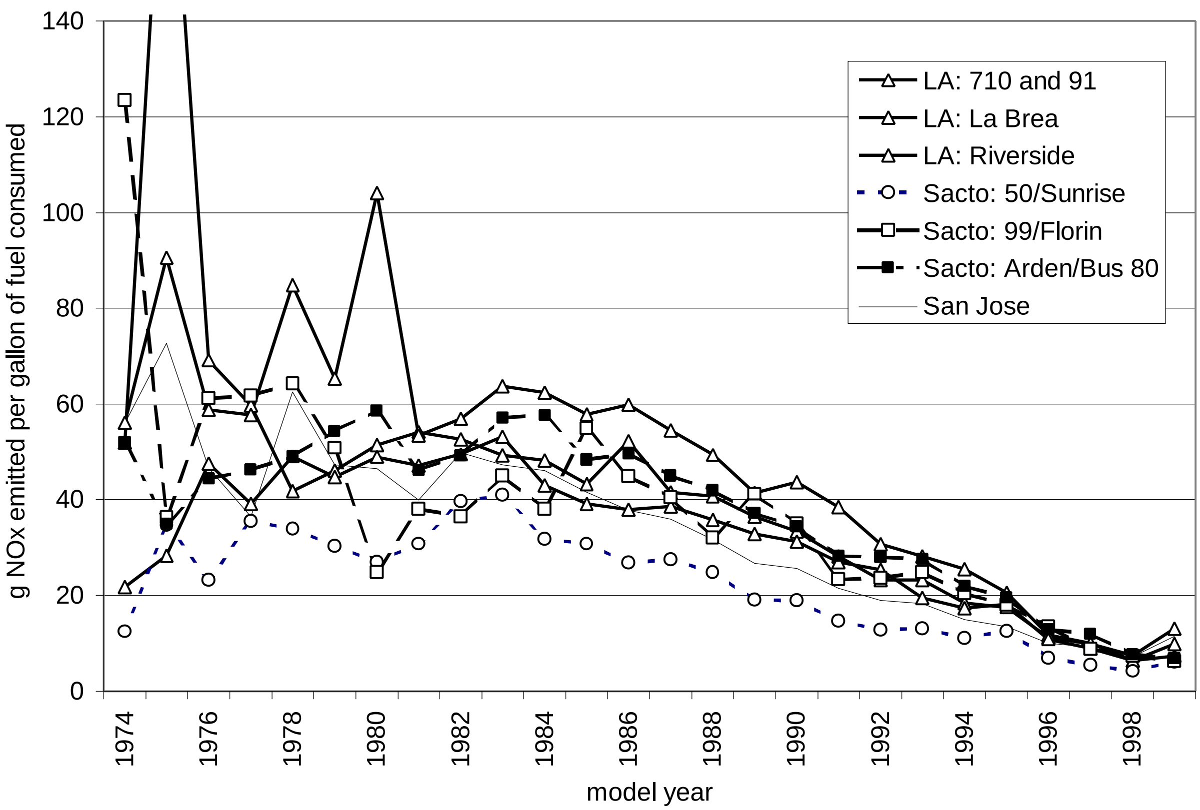


Figure F-3. NOx emissions at seven remote sensing sites



Second**,** HC emissions are higher at the Sacramento 50E and Sunrise site and substantially lower at the Sacramento 99 and Florin site. The site at 50E and Sunrise includes many more negative loads than at the other sites (meaning more vehicles were measured during deceleration), and we know that fleet-average emissions depend on vehicle load[2]. In particular, gram-per-gallon fleet-average HC emissions increase at negative loads, which explains the higher emissions at the 50E and Sunrise site. However, the much lower HC emissions at 99 and Florin road cannot be explained by vehicle load, and may indicate a calibration problem with the instrument. Overall, emissions of all three pollutants are much more similar at the three Los Angeles are sites than they are at the Sacramento sites.

For these reasons, we decided to group together all of the Los Angeles area data and focus our analysis on these data. These sites are the exit ramp from northbound 91 to westbound 60 in Riverside (Riverside), the entrance ramp to eastbound Freeway 10 from LaBrea (LaBrea), and the Interstate 710 and State Highway 91 interchange (710 and 91)**.** The Riverside measurements were made from June 28 to July 7, 1999, and the others were made from November 3 to 13, 1999. The Sacramento data could have been analyzed separately for each site, but there are an insufficient number of measurements at each site for a conclusive evaluation. The San Jose data

2. Brett Singer, Ph.D. thesis (U.C. Berkeley 1998)

were not relevant to the current analysis of Enhanced program effectiveness because San Jose is not an Enhanced I/M area.

As mentioned, fleet-average emissions depend on vehicle load. The load dependence of gram-per-gallon emissions factors is, in general, much less than gram-per-mile emissions factors.[3] The most important load effects for CO and HC appear to be the increased emissions that result at negative loads. NOx emissions increase almost linearly over a wide range of positive loads. Most of the remote emissions data were collected from vehicles travelling at loads similar to those encountered during the ASM test (roughly in the range of 5 to 10 kW/tonne).

Vehicle specific power (VSP) is an estimate of the instantaneous load experienced by the vehicle at the moment of the emissions measurement. "Load" refers to the resistances or barriers to vehicle movement that must be overcome by the engine. The constants in each equation carry units to make each resistance's units kW/tonne; these include:

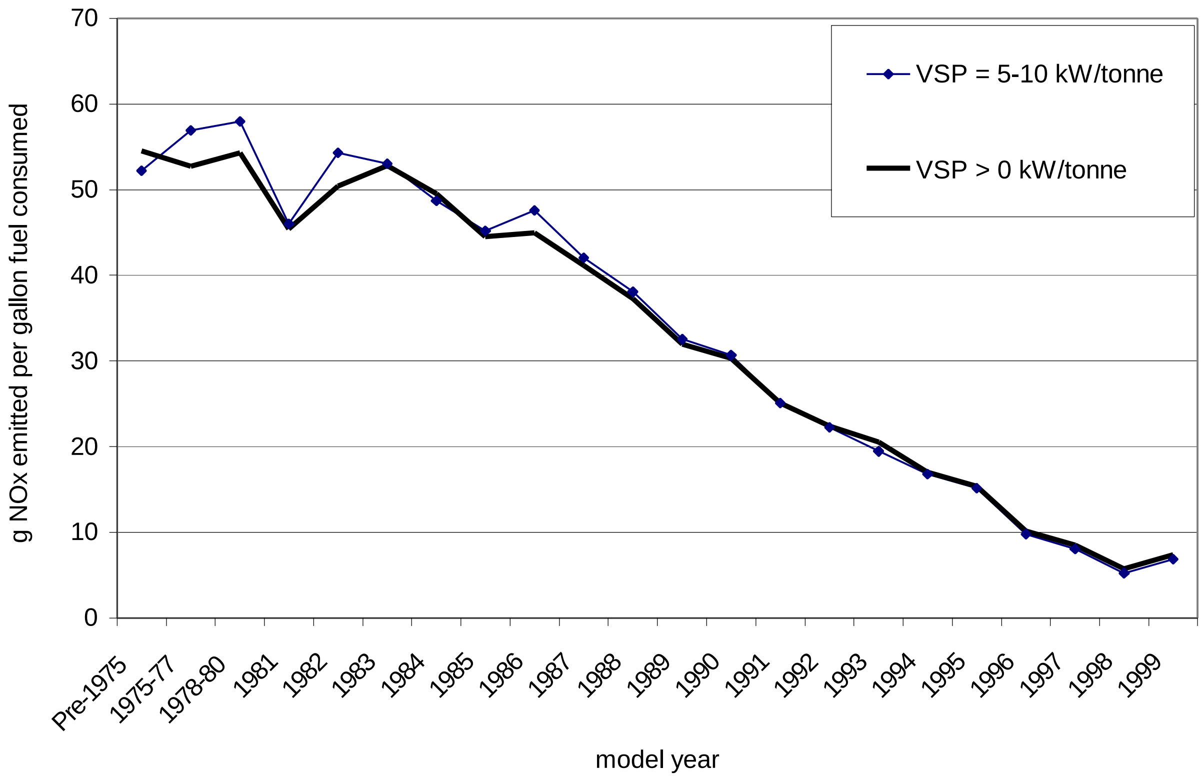
Rolling resistance = $0.0657 \times$ speed (mph)
Inertial resistance = $0.22 \times$ speed (mph) $\times$ acceleration (mph/sec)
Air drag resistance = $0.0000217 \times [\text{speed (mph)}]^3$
Gravitational resistance = $4.363 \times \sin$[roadway grade (radians)] $\times$ speed (mph)
VSP (kW/tonne) = Rolling + Inertia + Air drag + Gravity

As formulated, the total load is normalized to a typical vehicle mass.[4]

Figure F-4 shows average NOx emissions by model year for all of the Los Angeles area data for two cases: including only those measurements with VSP in the range of 5 to 10 kW/tonne and including all measurements with positive VSP (greater than 0). This figure shows that the larger VSP range does not affect average emissions. Since we were limited in the amount of data available, we chose to perform our analyses on all measurements with positive vehicle load. (Even using this larger data set, the number of measurements was still insufficient to develop precise estimates of program benefits, as explained below).

3. Brett Singer, Ph.D. thesis (UC-Berkeley 1998)
4. A more detailed description of these terms, including the typical vehicle coefficients used to develop them, is provided in the Ph.D. thesis of Jose L. Jimenez (MIT, 1998); the Ph.D. thesis of Brett C. Singer (UC-Berkeley, 1998) also describes the terms in more detail.

Figure F-4. NOx emissions at Los Angeles area sites: inclusion of only loads comparable to the ASM, or of all positive loads.



F.3. Data analysis

Vehicles measured by remote sensing were grouped according to Smog Check status by matching the remote sensing record to the Smog Check database using first the vehicle license number, and when available, the vehicle identification number (VIN). The number of vehicles with matching Smog Check records is shown in Table F-1.

As in the analysis of roadside tests, we compared the remote sensing emissions of an Untested fleet with those of a Tested fleet. For the remote sensing data, Untested vehicles were defined as having their last Basic Smog Check test more than 12 months before the remote sensing measurement and/or an Enhanced test after the remote sensing measurement. Tested vehicles had an Enhanced Smog Check before their remote sensing measurement.
Figures F-5 and F-6 show the average gram-per-gallon emissions factors of the Tested and Untested fleets, as measured by remote sensing. To reduce the uncertainty of each average emissions factor, we grouped together vehicles from the following model years: 1974 to 1980, 1981 to 1983, and 1984 to 1985. These figures show that there is almost no difference between CO emissions of the two fleets for 1989 and newer vehicles, and that the differences are small even for older vehicles. For HC, differences are even smaller.

Figure F-5. On-road HC emissions of vehicles that have and have not yet received an Enhanced Smog Check test. Emissions measured by remote sensing at three sites in greater Los Angeles

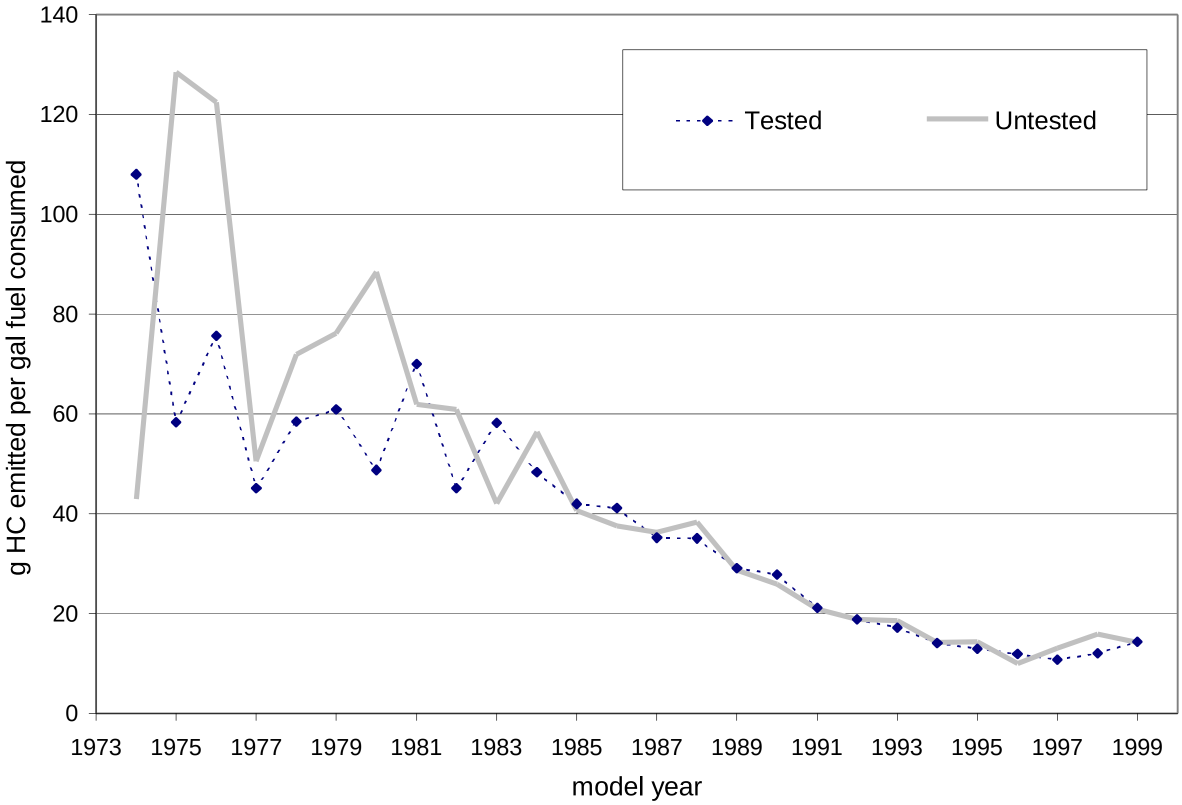
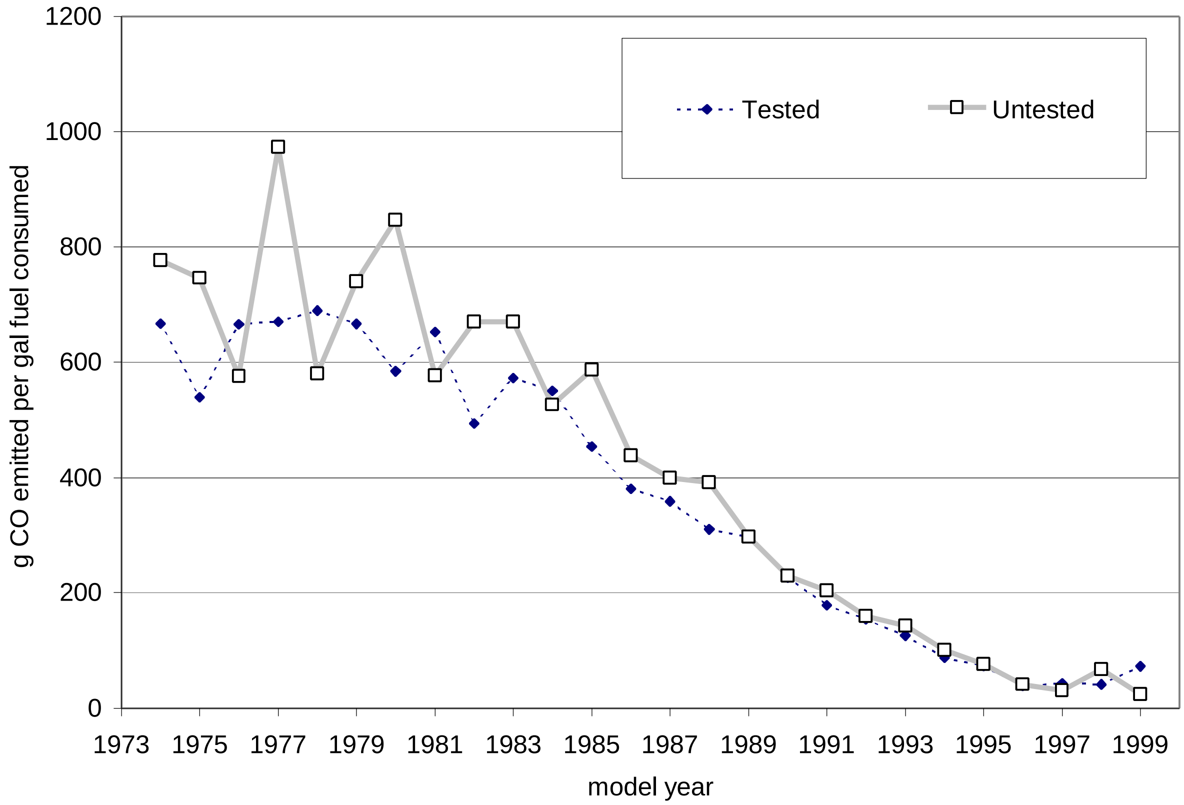


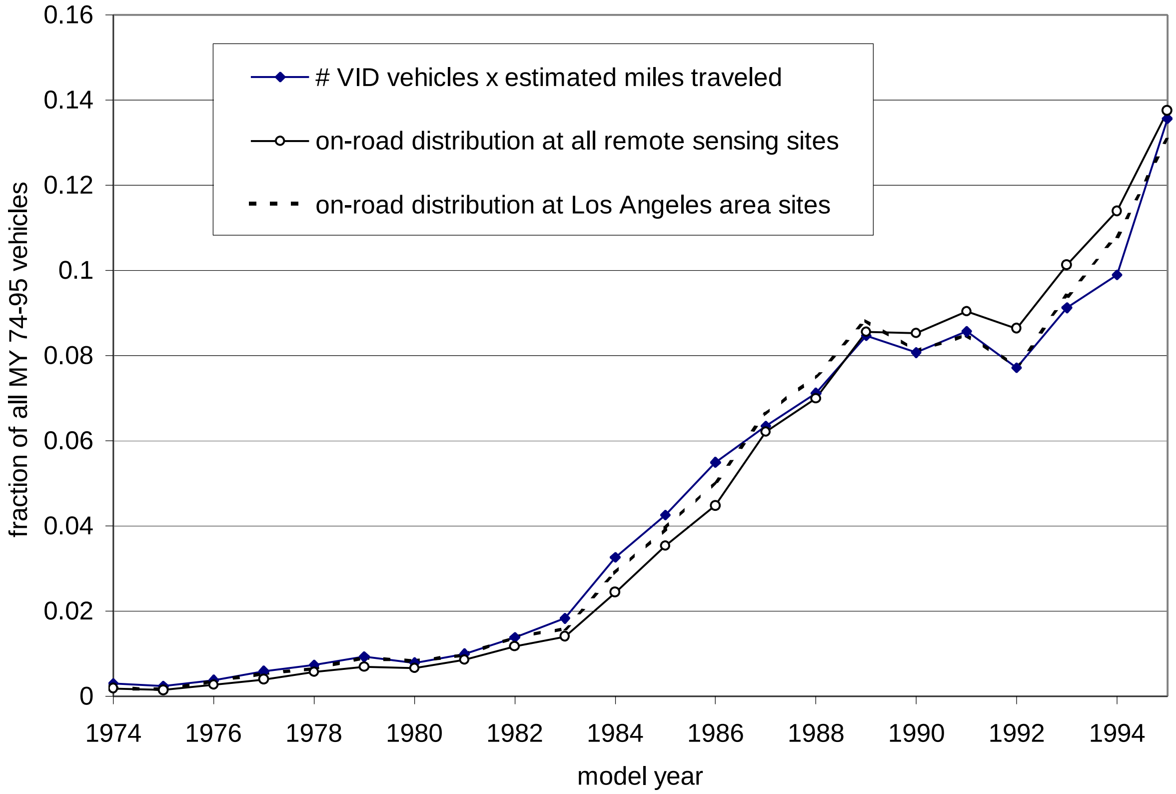
Figure F-6. On-road CO emissions of vehicles that have and have not yet received an Enhanced Smog Check test. Emissions measured by remote sensing at three sites in greater Los Angeles



The emissions factors shown in Figures F-5 and F-6 were used to estimate an overall program benefit based on remote sensing data. To accomplish this, the emissions factors were combined with the vehicle counts, estimated VMT and estimated fuel economy by model year as described in Appendix D.

An overall percent reduction was estimated by comparing the total tons per day emissions of the Tested and Untested fleets. The percent reduction was also estimated by calculating overall fleet-average emissions factors for the tested and untested fleets based on the observed on-road age distribution. This is analogous to (and comparable to) the travel distribution that is calculated by combining the vehicle counts and travel estimate values in Appendix D. A comparison of the on-road vehicle travel distribution measured by remote sensing, and estimated using the VID vehicle counts multiplied by estimated miles traveled by model year, is shown in Figure F-7.

Figure F-7. Comparison of vehicle model year distribution observed by on-road remote sensing and as calculated from VID vehicle counts and estimated average miles traveled per model year



The time-series analysis shown in Figure 8 in Section 4.2.2 of the report was developed in much the same way, except that emissions factors were calculated separately for vehicles that were measured on-road at different time periods after their Enhanced Smog Check**.** For the time-series analysis, we calculated the amount of time between the Enhanced Smog Check test and the remote sensing measurement. The overall fleet-average emissions factors for each of these vehicle groups were again compared to the control group of Untested vehicles. The emissions factors and vehicle counts by model year group are provided in Figures F-8 through F-11. Note that emissions factors are lowest up to three months and three to six months after testing, but that even for these groups, HC and CO emissions are not much lower than, and NOx emissions are almost indistinguishable from, those of the Untested group.

Figure F-8. HC emissions factors by model year used to calculate average emissions factors for Figure 8 in Section 4.2.2. Vehicles grouped by the time since their Enhanced Smog Check test. Emissions measured on-road by remote sensing at three sites in greater Los Angeles area.

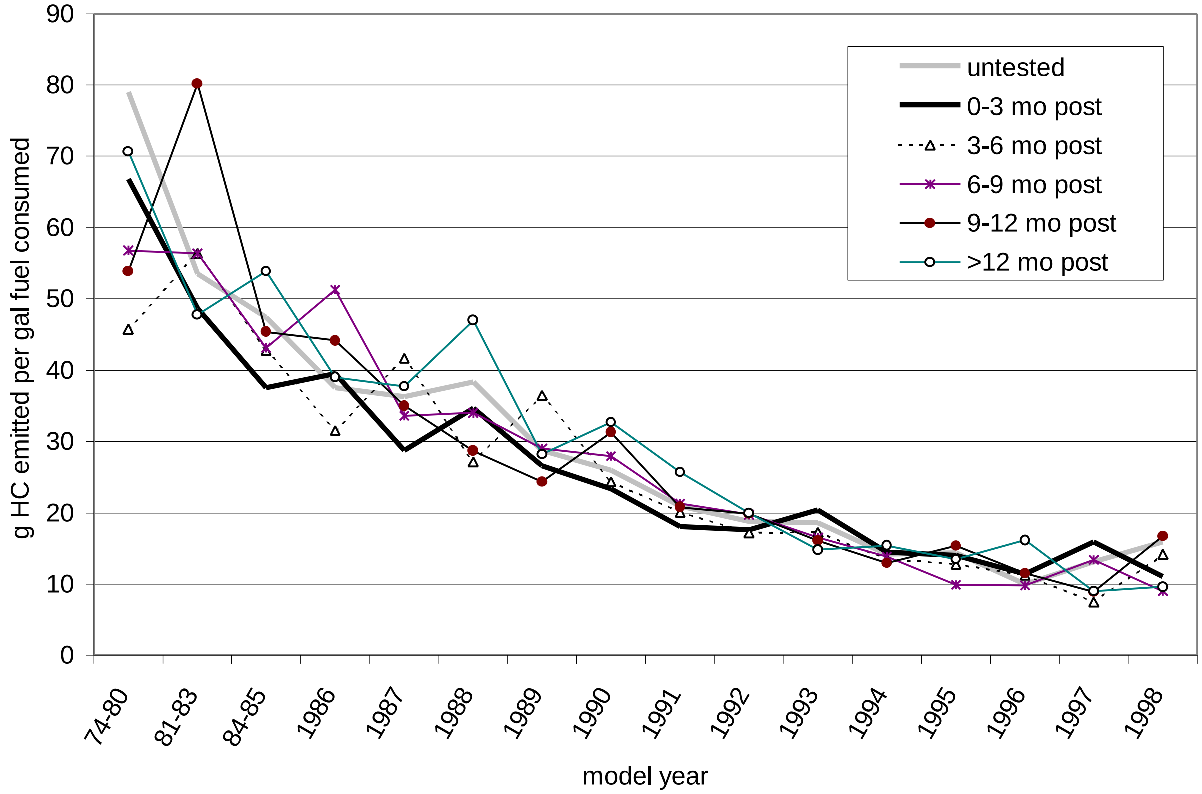


Figure F-9. CO emissions factors by model year used to calculate average emissions factors for Figure 8 in Section 4.2.2. Vehicles grouped by the time since their Enhanced Smog Check test. Emissions measured on-road by remote sensing at three sites in greater Los Angeles area.

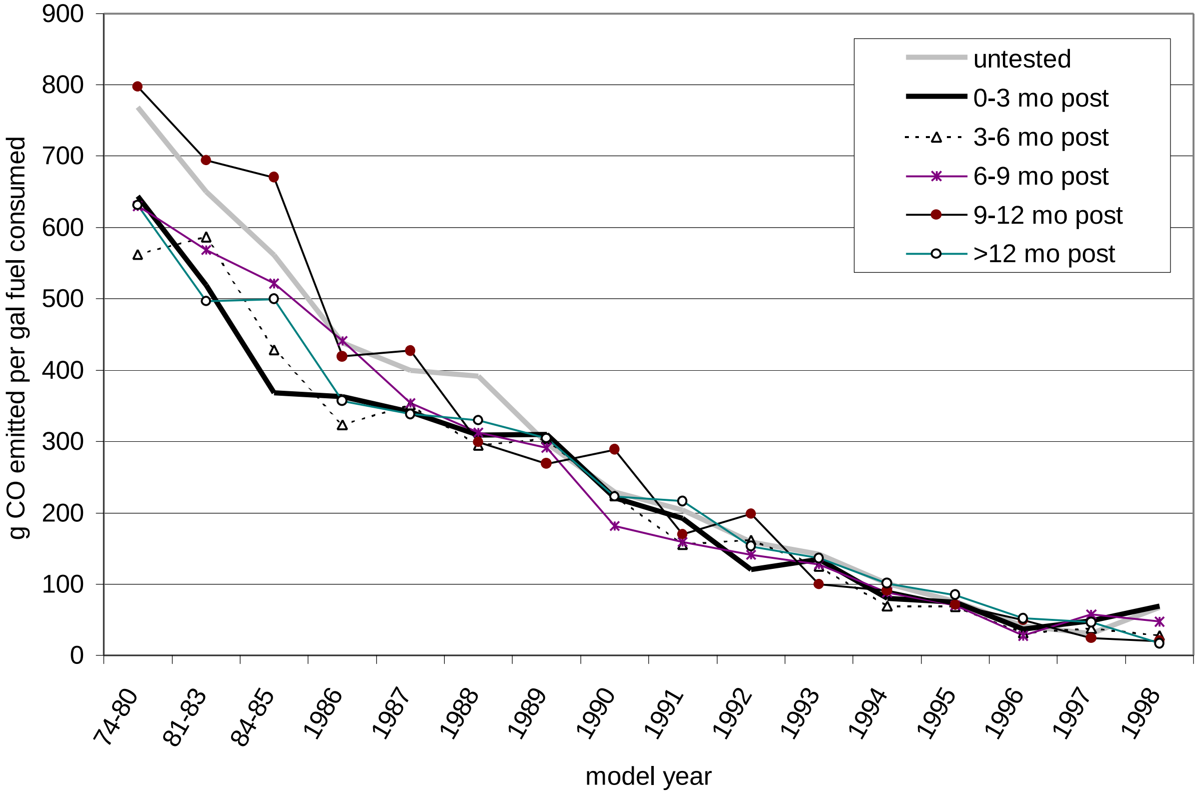


Figure F-10. NOx emissions factors by model year used to calculate average emissions factors for Figure 8 in Section 4.2.2. Vehicles grouped by the time since their Enhanced Smog Check test. Emissions measured on-road by remote sensing at three sites in greater Los Angeles area.

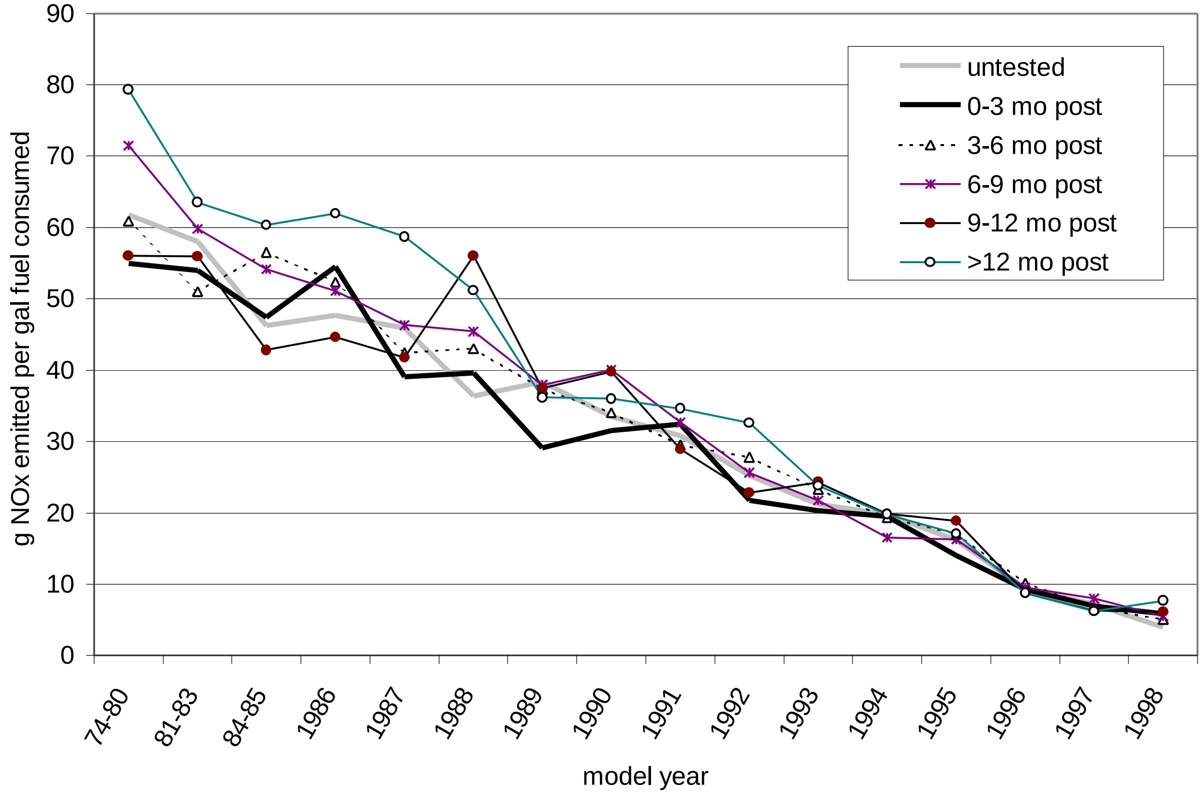
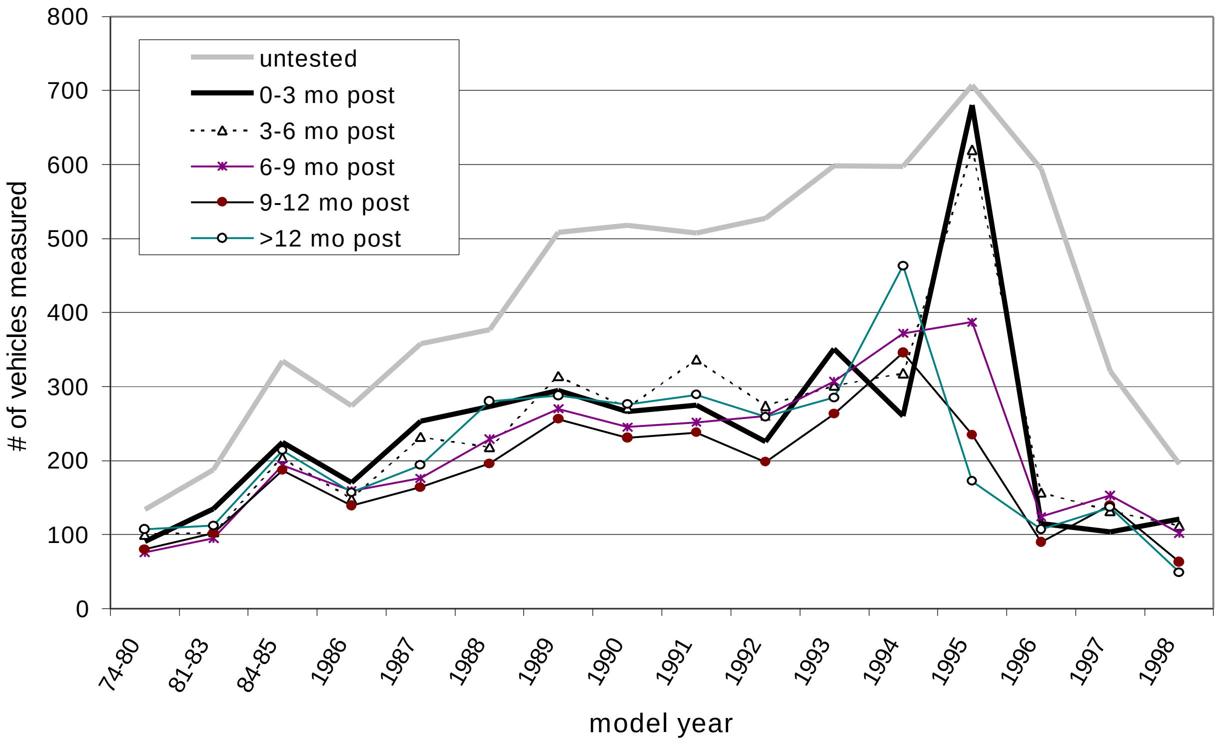


Figure F-11. Number of measurements used to calculate emissions factors by model year for Figures F-8 through F-10. Vehicles grouped by the time since their Enhanced Smog Check test. Emissions measured on-road by remote sensing at three sites in greater Los Angeles



Finally, we used the remote sensing data to estimate the emissions contributed by vehicles currently not participating in the program. Vehicles with an Enhanced Smog Check test through the end of February 2000 were grouped into the Enhanced Smog Check fleet. This period includes the first 21 of the first 24 months of the Enhanced program, so we would expect that about 88% of the vehicles should be in the Enhanced group. Vehicles with no record of an Enhanced test, but with a recorded BAR90 test at any time since 1998, were classified as vehicles tested in the Basic program. Vehicles with no test record were grouped separately. We apportioned the total mass emissions of the on-road fleet to these three groups as follows. We multiplied average emissions by the number of vehicles in each group observed on-road, again by model year, and divided by the estimated fuel economy by model year. We then summed all the mass emissions and apportioned by model year and Smog Check group. These results are summarized in Figures F-12 through F-14.

Figure F-12. Apportionment of HC emissions measured by on-road remote sensing at three sites in greater Los Angeles area

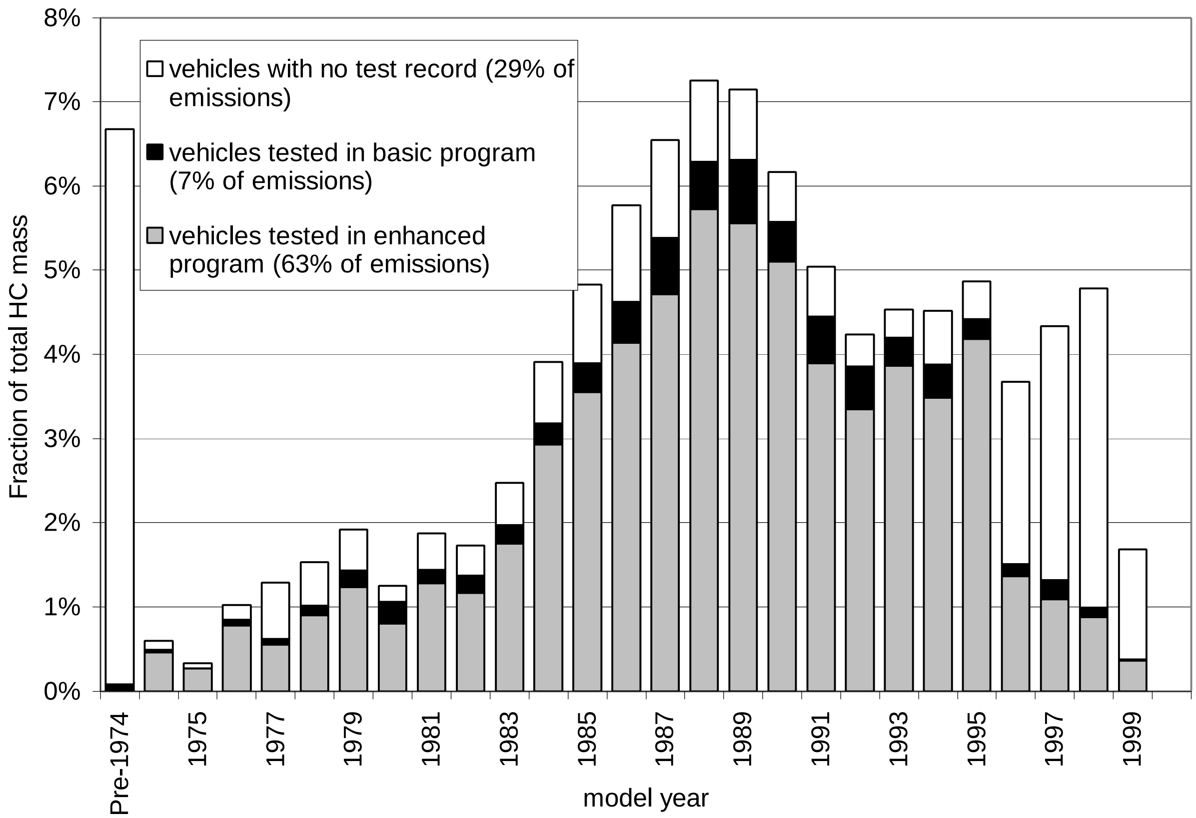


Figure F-13. Apportionment of CO emissions measured by on-road remote sensing at three sites in greater Los Angeles area

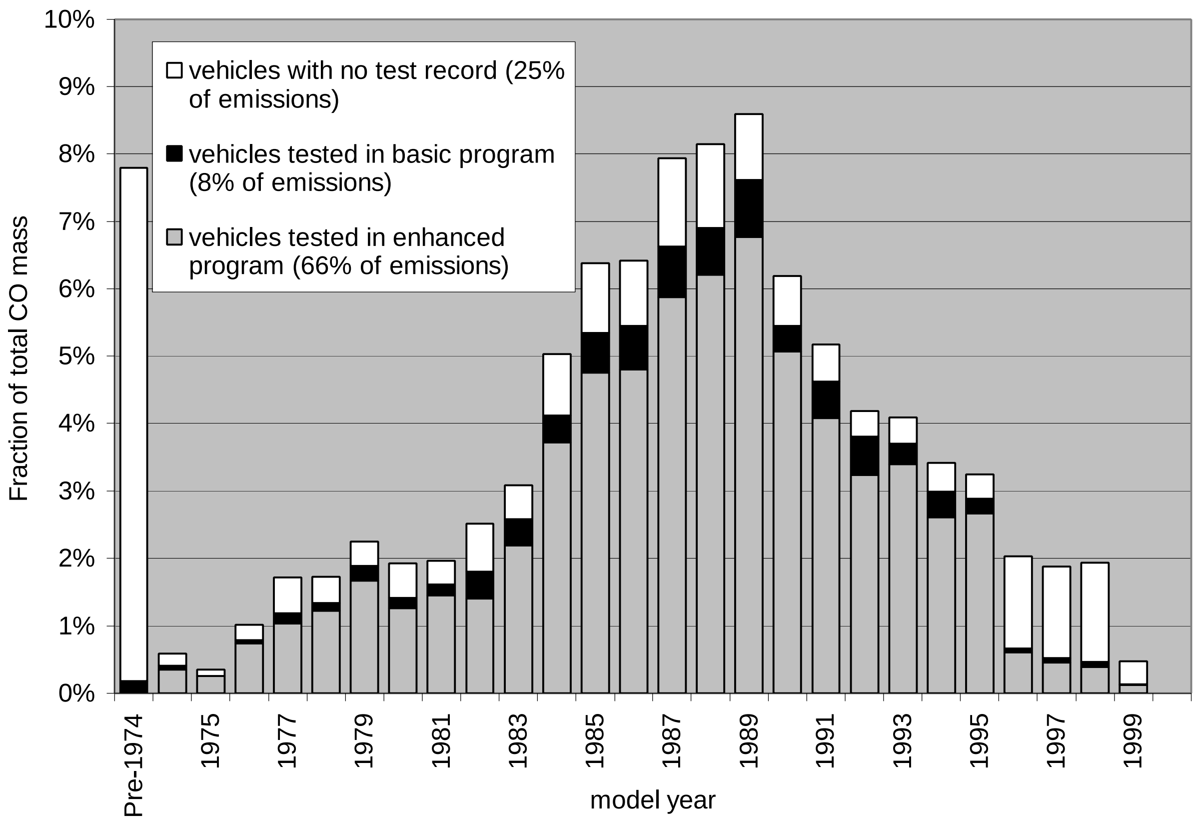


Figure F-14. Apportionment of NOx emissions measured by on-road remote sensing at three sites in greater Los Angeles area

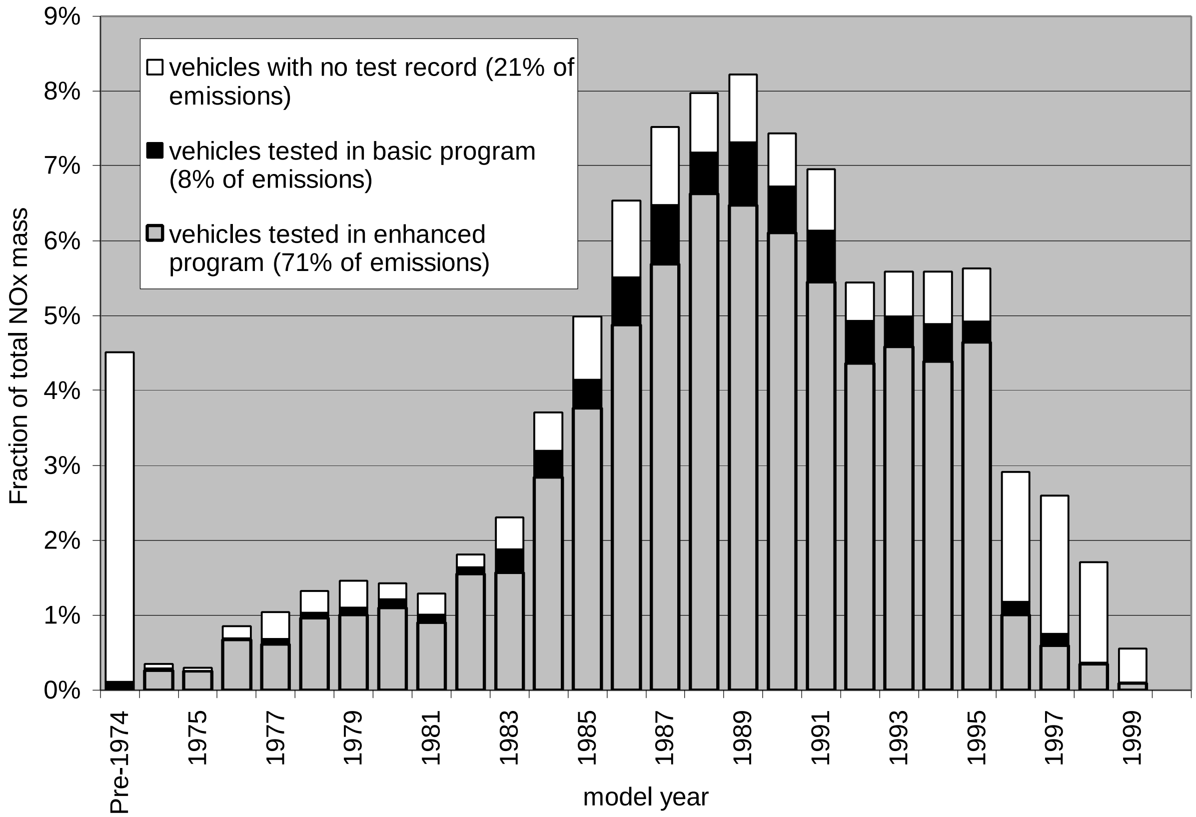


Table F-2 shows that 1973 and older vehicles, which account for only 1% of on-road vehicles, account for 4% to 8% of all on-road emissions, depending on the pollutant. 1996 and newer vehicles not tested under Smog Check[5], which make up 22% of the fleet, account for 5% to 10% of all on-road emissions, depending on the pollutant. 8% of all remote sensing measurements come from vehicles eligible for Smog Check testing, but with no record of a Smog Check test. These vehicles account for 12% to 13% of all on-road emissions.

Table F-2. Fraction of Remote Sensing Emissions from Exempted Vehicle Groups, South Coast Air Basin

Vehicle group	Percent of Readings	Percent of Emissions		
		HC	NOx	CO
1973 and older	1%	7%	4%	8%
1996 and newer	22%	10%	5%	5%
All exempted vehicles	23%	17%	9%	13%

5. These are vehicles that were first sold in California; 1996 and newer vehicles that were purchased in other states and subsequently re-registered in California are required to have a Smog Check test.